Soil from an Abandoned Manganese Mining Area (Hunan, China): Significance of Health Risk from Potentially Toxic Element Pollution and its Spatial Context

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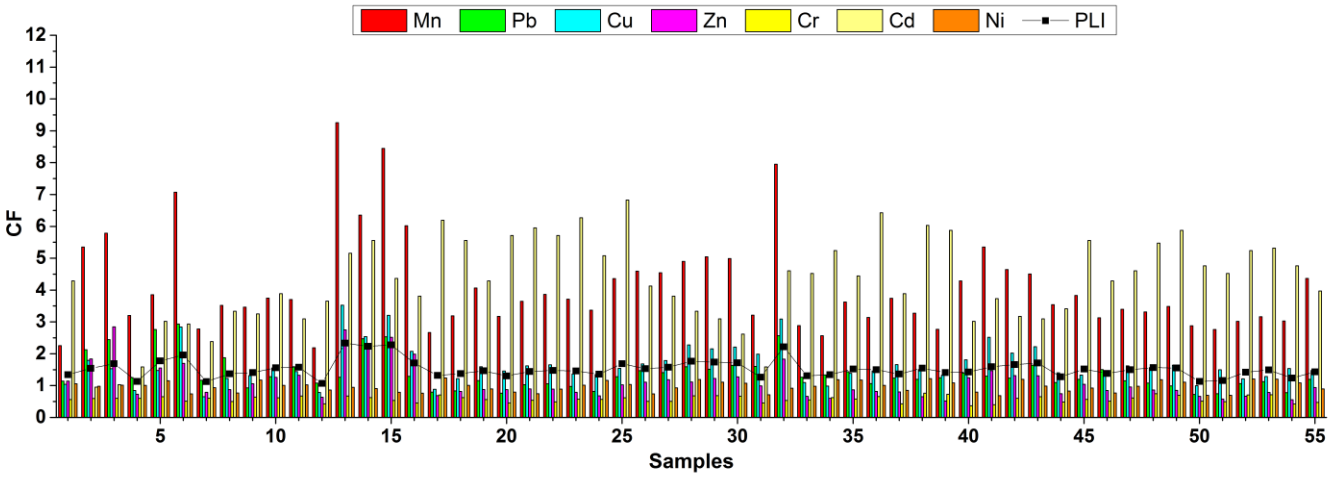

Figure S1 The contamination factors and pollution load index of PTEs in soil

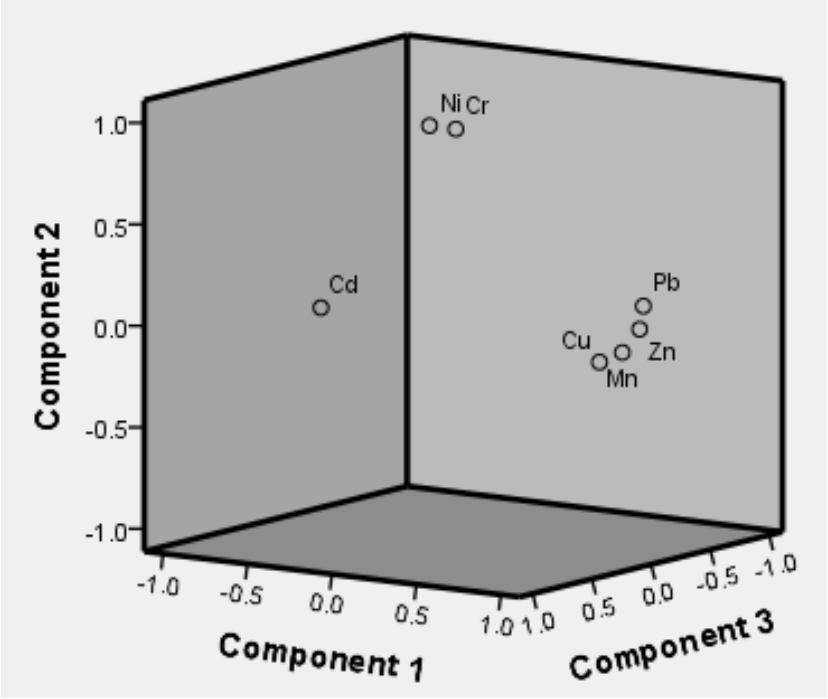

Figure S2 Load diagram in rotating space

Table S1 levels of I_{geo}, CF and PLI

I_{geo}	Pollution level	CF	Pollution level	PLI	Pollution level
$I_{geo}\leq 0$	Uncontamination	CF≤1	Low contamination	PLI<1	Low contamination
$0<I_{geo}\leq 1$	Uncontamination to moderate contamination	1<CF≤3	Moderate contamination	1≤PLI<2	Moderate contamination
$1<I_{geo}\leq 2$	Moderate contamination	3<CF≤6	Considerable contamination	2≤PLI<3	Considerable contamination
$2<I_{geo}\leq 3$	Moderate to heavy comtamination	CF>6	Very high contamination	PLI≥3	Very high contamination
$3<I_{geo}\leq 4$	Heavy comtamination				
$4<I_{geo}\leq 5$	Heavy to extreme contamination				
$I_{geo}>5$	Extreme contamination				

Table S2 Potential ecological risk index classification standard

E_r^i	Pollution level	RI	Pollution level
$E_r^i<40$	Low ecological risk	RI<150	Low ecological risk
$40 \leq E_r^i<80$	Moderate ecological risk	150≤RI<300	Moderate ecological risk
$80 \leq E_r^i<160$	Considerable ecological risk	150≤RI<300	Considerable ecological risk

$160 \leq E_r^i$<320	High ecological risk	150≤RI<300	High ecological risk
$E_r^i \geq 320$	Very high ecological risk	RI≥600	

Table S3 Exposure factors used in estimation for non-carcinogenic risk and carcinogenic risk.

Variables	Value
IR (mg/day): Soil ingestion rate	100 (adult); 200 (children)
EF (days/year): Exposure frequency	350 days
ED (years): Exposure duration	25 (adult); 8(children)
BW (kg): Average body weight	60 (adult); 25 (children)
AT (days): Averaging time	365×ED adult/children(non-carcinogenic); 365×70 (carcinogenic risk)
SA (cm^2): Skin surface that are available for exposure	5700 (adult); 2800 (children)
AF_s (mg/cm^2): Soil to skin adherence factor	0.07 (adult); 0.2(children)

Adapted from USEPA (1997; 2002; 2009; 2013).

Table S4 Some parameter values of various PTEs

Metal	Relative bioavailability factor(RBA) (unitless)	Dermal absorption fraction (ABS_d) (unitless)	Oral reference dose (RfD_o) (mg/kg·day)	Oral slope factor (CSF_o) $(mg/kg·day)^{-1}$	Gastrointestinal Absorption (GIABS) (unitless)	Inhalation reference concentration (RfC) (mg/m^3)	Particulate emission factor (PEF) (m^3/kg)	Inhalation unit risk (IUR) $(\mu g/m^3)^{-1}$
Mn	1	0.001	2.4×10^{-2}	-	0.04	5.0×10^{-5}	1.36×10^{9}	-
Pb	1	0.001	3.5×10^{-3}	-	1	-	1.36×10^{9}	-
Cu	1	0.001	4.0×10^{-2}	-	1	-	1.36×10^{9}	-
Zn	1	0.001	3.0×10^{-1}	-	1	-	1.36×10^{9}	-
Cr	1	0.001	3.0×10^{-3}	0.5	0.025	1.0×10^{-4}	1.36×10^{9}	8.4×10^{-2}
Cd	1	0.001	1.0×10^{-3}	-	0.025	1.0×10^{-5}	1.36×10^{9}	1.8×10^{-3}
Ni	1	0.001	2.0×10^{-2}	-	0.04	9.0×10^{-5}	1.36×10^{9}	2.6×10^{-4}
References	USEPA[36]	USEPA[31]	USEPA[37]	USEPA[37]	USEPA[37]	USEPA[37]	USEPA[37]	USEPA[37]

Table S5 The distribution of I_{geo} and E_r^i of PTEs at each level

	I_{geo}							E_r^i				
	Class1	Class2	Class3	Class4	Class5	Class6	Class7	Class1	Class2	Class3	Class4	Class5
Mn		16.4%	72.7%	10.9%				100%				
Pb	41.8%	43.7%	14.5%					100%				
Cu	20.0%	56.4%	23.6%					100%				
Zn	80.0%	10.9%	9.1%					100%				
Cr	100%							100%				
Cd	3.6%	9.1%	78.2%	9.1%				3.6%	7.3%	63.6%	25.5%	
Ni	100%							100%				

Table S6 Non-carcinogenic risk hazard quotient (HQ) and risk index (HI)

	Adult				child			
element	HQ_{ing}	HQ_{der}	HQ_{inh}	HI	HQ_{ing}	HQ_{der}	HQ_{inh}	HI
Mn	1.25×10^{-1}	1.25×10^{-2}	2.65×10^{-2}	1.64×10^{-1}	6.00×10^{-1}	4.20×10^{-2}	2.65×10^{-2}	6.69×10^{-1}
Pb	1.87×10^{-2}	7.44×10^{-5}		1.87×10^{-2}	8.96×10^{-2}	2.51×10^{-4}		8.98×10^{-2}
Cu	1.80×10^{-3}	7.18×10^{-6}		1.81×10^{-3}	8.64×10^{-3}	2.42×10^{-5}		8.66×10^{-3}
Zn	5.60×10^{-4}	2.23×10^{-6}		5.62×10^{-4}	2.69×10^{-3}	7.52×10^{-6}		2.69×10^{-3}
Cr	2.20×10^{-2}	3.51×10^{-3}	2.91×10^{-4}	2.58×10^{-2}	1.05×10^{-1}	1.18×10^{-2}	2.91×10^{-4}	1.18×10^{-1}
Cd	8.58×10^{-4}	1.37×10^{-4}	3.78×10^{-5}	1.03×10^{-3}	4.12×10^{-3}	4.61×10^{-4}	3.78×10^{-5}	4.62×10^{-3}
Ni	2.47×10^{-3}	2.47×10^{-4}	2.42×10^{-4}	2.96×10^{-3}	1.19×10^{-2}	8.31×10^{-4}	2.42×10^{-4}	1.29×10^{-2}
Total	1.71×10^{-1}	1.64×10^{-2}	2.70×10^{-2}	2.15×10^{-1}	8.22×10^{-1}	5.54×10^{-2}	2.70×10^{-2}	9.05×10^{-1}

Table S7 Carcinogenic risk under exposure pathways

Element	Cr	Cr	Cr	Cd	Ni	
Pathway	CR_{ing}	CR_{der}	CR_{inh}	CR_{inh}	CR_{inh}	TCR
CR	2.98×10^{-5}	3.90×10^{-6}	2.79×10^{-7}	7.78×10^{-11}	6.48×10^{-10}	3.40×10^{-5}